San Francisco Water Power Sewer
Services of the San Francisco Public Utilities Commission

"Still" Waters

Lesson Plan Grades 4 - 6

Lesson Summary

Students make a solar still to observe different stages of the water cycle and to learn about desalination.

Overview

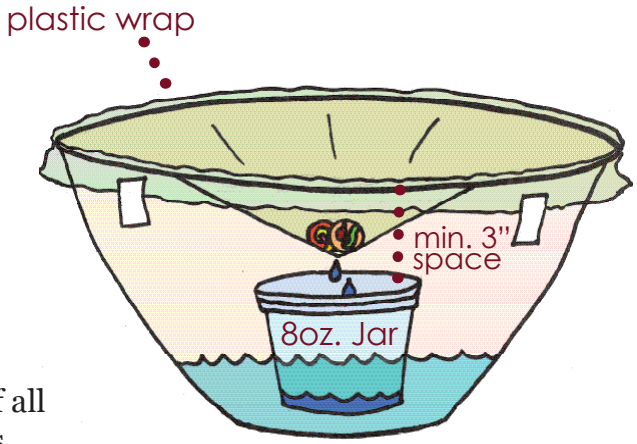
In this lesson, students will:

- Identify the stages of the water cycle
- Learn how distillation is one way to desalinate saltwater
- Predict outcomes in a simple experiment

Background

Every living thing needs water to survive. While 97% of all water on Earth is saltwater, the amount we can actually use as freshwater is less than 1%--about 0.34%. Solar energy and gravity power the water cycle, which is nature's way of recycling and purifying water. Evaporation occurs when the sun heats up water in soil, plants, oceans, lakes and streams, and turns it into invisible vapor. Condensation occurs when water vapor collects together and changes back into liquid, becoming part of mist, dew, fog or clouds. Precipitation occurs when so much water has condensed, the air cannot hold it anymore. Clouds get heavy and gravity pulls the water down in the form of rain, hail, sleet or snow. Accumulation results after water falls to earth and collects. It may fall into oceans, lakes or rivers, or onto land where it soaks into the earth and becomes groundwater. This is what provides water to springs and wells. Precipitation can also run over soil as surface run-off and collect in bodies of water where the cycle starts all over again.

California is a dry state that is prone to droughts, which decreases our water resources. Add this to a growing population, and California will need more water supplies to meet future demand. Since the San Francisco Bay Area is a coastal region, a desalination plant could provide local residents with a new source of freshwater. By removing salt from seawater through reverse osmosis (which uses intense pressure to filter water through membranes), a desalination plant could produce 71 million gallons of freshwater every day. Another way to desalinate smaller amounts of water, is a much simpler method in practice since ancient times. Using heat (from the sun or other sources), distillation separates freshwater from saltwater through evaporation and condensation. This process is actually the water cycle at work!

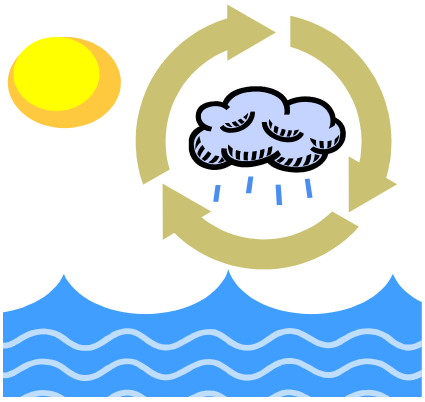


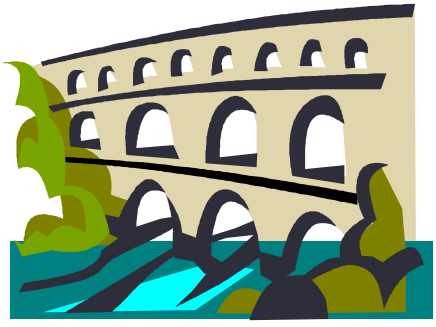
Time

Two 45-minute class periods

Materials

- 5 glass or ceramic bowls (large enough to hold 64 oz.)
- 5 short glass jars (8 oz. is ideal)
- Clear, graded, measuring cups
- Measuring spoons
- Clean eye-dropper
- Tape
- Clear plastic wrap
- Small weights like marbles
- 1 cup sea salt
- Pitcher of tap water
- Stirring spoons or sticks
- Overhead projector
- Transparency of Water Cycle
- 5 large sheets black construction paper (optional)
- "Still" Waters Student Worksheet
- *What is a Drought?* and *Desalination* Fact Sheets (optional)





Preparation

- Make Transparency of Water Cycle Graphic (attached at end)
- Look up weather forecast for the week. Conduct expriment in the morning on the sunniest days of the week so that solar still has longest possible exposure to sunlight.
- Divide class into 5 groups.
- (optional) Make student copies of Fact Sheets, Comprehension Questions, and Worksheet.
- (optional) Have students read fact sheets in groups or as a class. Can also be assigned independently as homework.
- Assemble a set of solar still materials for each group.

Pre-Activity Questions

Ask students:

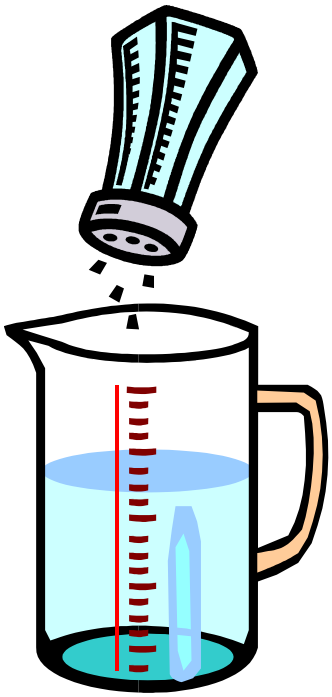
1. Why is freshwater one of the most important things on our planet? (*All people and many other living things on Earth need freshwater for survival. We can survive weeks without food, but only a few days without water.)*
2. What do we use freshwater for? Write answers on board. (*Cooking, cleaning, bathing, drinking, agriculture, irrigation, industrial production, municipal uses like firefighting, etc.)*
3. Whether we see it or not, just about everything we do and everything we use needs water in some form or another!
4. Where does our freshwater come from? What is the system on Earth that continues to provide us with freshwater? (*Display overhead image of Water Cycle Graphic Transparency*.)
5. Explain Water Cycle: Gravity and energy from the sun power the water cycle. As the heat of the sun (solar energy) evaporates the water from the lake, this water turns into an invisible gas or vapor and floats up into the atmosphere leaving dirt, salts, and other substances behind. As the water molecules gather in the air, they condense or form into mist, fog, or a cloud. When enough water gathers in the cloud, gravity pulls the water down in the form of precipitation, also known as rain, snow or sleet. As the rain falls, it accumulates or gathers in bodies of water like oceans and lakes, or it soaks into the ground where it becomes groundwater. Groundwater gets filtered through all the sand, soil and rock that make up the Earth's geological layers and when enough water collects underground it forms aquifers, which is sort of like an underground lake that feeds natural springs.
6. There has always been the same amount of water on Earth. The water you used this morning to brush your teeth could be the same water ancient Romans transported through their aqueducts!
7. Although it seems like there is a lot of water on our planet, 97% of the Earth's water is saltwater and only 3% is freshwater.

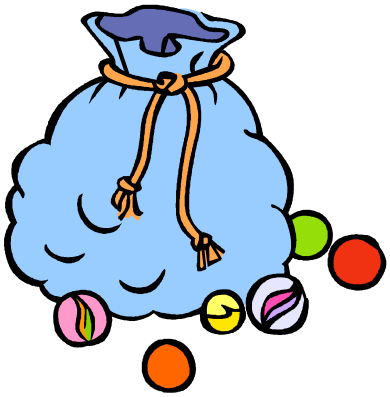
However, only about 0.34% of all water on Earth is freshwater that is available for humans to use because more than half of the Earth's freshwater is frozen and the rest is in the atmosphere, deep underground, or polluted. That's like having 100 dollars in the bank but only being able to spend 34 cents!

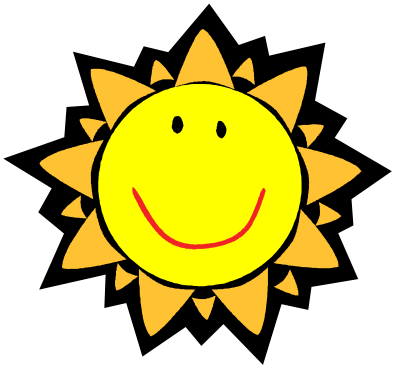
8. Ask students: What is a drought? (*A drought is a long period of time when normal levels of precipitation do not fall and water supplies start to dry up.*)
9. Do we have droughts in California? (*Yes. California is a dry state that is prone to droughts from time to time.*)
10. Since California tends to have droughts, and since the San Francisco Bay Area is right next to the ocean, what method might we use some day to create freshwater from saltwater? (*Desalination.*)
11. What does "desalination" mean? (*It means "removing salt" from seawater or saltwater, and is a method of creating freshwater that we can drink. Desalination can happen with very simple materials, or in large desalination plants that can produce millions of gallons of freshwater a day.*)
12. What are two methods for desalination? (*Distillation: Evaporating saltwater so that fresh water distills or separates out from the saltwater. Reverse osmosis: The process of forcing saltwater through a membrane that filters out the salt and lets the freshwater pass through. Reverse Osmosis is the method used in desalination plants because it produces the most amount of freshwater.*)

Procedure

1. Tell students they will now do an activity to desalinate saltwater through distillation by creating a solar still.
2. Distribute "Still" Waters Worksheets to each student.
3. Distribute solar still materials to each group.
4. Have student groups make saltwater for their solar still. Mix 1 tablespoon of salt and 2 cups of water into their bowl. Stir solution until salt completely dissolves. (*Note: Average salinity in the ocean is 35 parts per thousand or 3.5%. 1 tablespoon of salt for 32 tablespoons of water (2 cups) is about 3.5%*)
5. Use a dropper to extract saltwater from each group's bowl. Have each student stick out their tongues and drop 1-2 drops of salt water solution for them to taste.
6. Using their Worksheet, have students rate the saltiness of this solution on a scale of 1-10, with 10 being the saltiest.
7. Place the glass jar in the middle of the bowl. It is very important that the rim of the jar is higher than the saltwater, but shorter







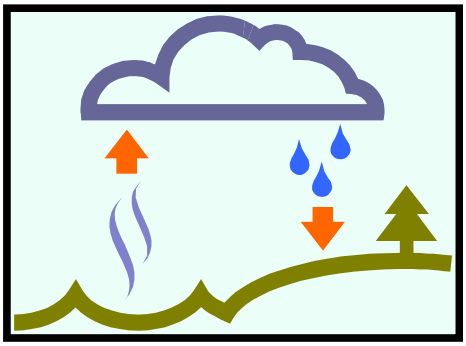
than the rim of the bowl. The difference between both rims should be at least 3 inches. (*see diagram on front page*)

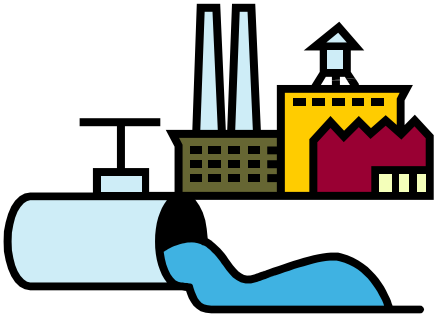
8. Cover top of the bowl with plastic wrap and secure the edges with tape so the bowl is sealed. Make sure that there is enough slack in the plastic wrap so that when weighted in the middle, it creates "V" shape. (*see diagram*)
9. Put 1 - 2 marbles or similar weights in center of plastic wrap, being careful not to break it. The weighted center should dip into the glass jar like a "V" but not seal the opening of the jar. Water drops will then be able to easily drip down the plastic wrap into the jar.
10. If possible, leave the stills outside in the sun where they won't be disturbed, or place them on a sunny ledge in the classroom for at least 6 hours of daylight for one-two days. You can also place stills on top of black construction paper to increase absorption of solar heat. (*Note: Since black absorbs light, freshwater will collect faster if there is something black underneath the still to absorb sunlight and convert it to heat.*)
11. Ask students to refer to their Worksheets and make predictions, which are educated guesses about what they think will happen. They should record these predictions on their Worksheet.
12. Have students observe their stills three times a day and use their Worksheets after each observation to note any transformations of water (e.g. droplets forming/condensing on the plastic wrap, water dripping/precipitating into jar, water accumulating in the jar). This will illustrate the water cycle as it works in nature.
13. After recording their observations, have students carefully move the still to follow the sun's movement through the day.
14. After one-two days of observation, remove the plastic wrap from the stills to see how much water has gathered in the jar. (*Note: If there is a lot of sun, one day may be enough.*)
15. Have students pour the distilled water into a measuring cup to see how much freshwater was created after distillation. Have them record findings on Worksheet. (*Note: Depending on how much water has accumulated, measuring may need to happen with tablespoons and teaspoons vs. measuring cups.*)
16. Using the dropper again (rinsed clear of saltwater from previous taste test), let students taste the distilled water. Ask students to observe what the distilled water tastes like (*is it fresh or salty?*) and record the degree of saltiness on their Worksheet.
17. Repeat "taste test" but this time use the leftover water (*brine*) in the bowl. Have students record saltiness on Worksheet.
18. Ask students to compare their predictions with their findings and to summarize what they learned at the bottom of their Worksheet.

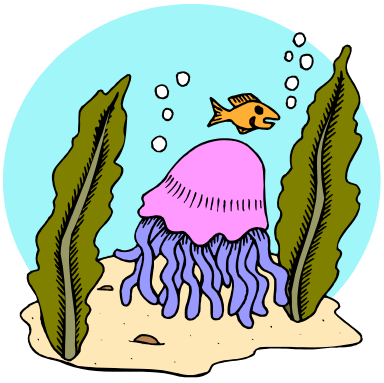
Note: Depending on how much sunlight is available, the amount of water that accumulates in the still can vary greatly. The key point is that sunlight converts to heat, which warms up the saltwater. To speed up the process, the still can be placed in a solar cooker, which can be easily assembled. To view directions for building a solar cooker, see lesson plan: "Cooking with the Sun!" http://sfenvironmentkids.org/teacher/lesson_plans/cooking_with_the_sun.pdf

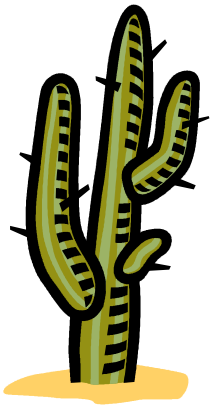
Follow-Up Discussion

1. After Worksheets are completed, ask students: What did you notice when you observed the solar still? Could you see the different stages of the water cycle as it happened? (*Evaporation cannot be observed because water vapor is invisible to the naked eye. Condensation should appear as liquid droplets on the plastic wrap. Precipitation should appear as water dripping into jar. Accumulation should appear as water that collected in jar.*)
2. How accurate were your predictions? How much water did you think was going to end up in the jar? Was it more or less than you expected? Take student answers.
3. What affected how much water accumulated in your jar? (*The amount of sunlight the still received will have affected the outcome. Like the earth's natural water cycle, the sun powers evaporation in the still by heating up the water. Less heat means less evaporation, condensation and accumulation.*)
4. Did you think that the water in the jar would be salty or fresh? On a scale of 1-10, how salty was the water collected in your jar? How did it compare with how salty the saltwater solution was before the experiment?
5. How do you think the distilled water in the cup became less salty than the original saltwater solution? (*Desalination occurring in the solar still is actually the water cycle at work! Heavy molecules like salt and other minerals get left behind as water vaporizes and travels upwards before condensing in clouds and falling as freshwater.*)
6. How salty was the water that was leftover in the bowl? Take student answers.
7. What is this salty by-product of desalination called? (*Brine.*) (*Note: Brine at a desalination plant will be much saltier than what's leftover in this classroom experiment. That's because the desalination plant will have been more efficient at removing fresh water from salt water, thereby leaving more concentrated brine behind.*)









8. When freshwater is created at a desalination plant, a lot of brine is produced. How can brine be a problem when it's discharged from a desalination plant back into the ocean? (*Since brine is highly concentrated with salts, discharging it into the ocean could harm marine life because there would be too much salt in one area of the sea. That's why great care must be taken to ensure brine is diluted with purified wastewater before it's sent back to the ocean.*)
9. Explain to students: Although this was a simple activity that showed how the water cycle works, you also learned about one way to desalinate water using the sun's energy. In some places like the deserts where it is very dry, or in towns and villages where water sources may be polluted, people distill their water using solar stills, to get potable water.
10. Desalination is one way we can create freshwater resources, but the most important thing we can do is to be smart about our water use and conserve or save the water we already have. What are some ways we can conserve water? (*Have students give their answers. Some examples are: fix leaky pipes; turn off faucets all the way; wear clothes more than once before putting in the laundry: turn off taps when brushing teeth or doing dishes; eat less beef and more plant based foods, etc.*)

Extensions

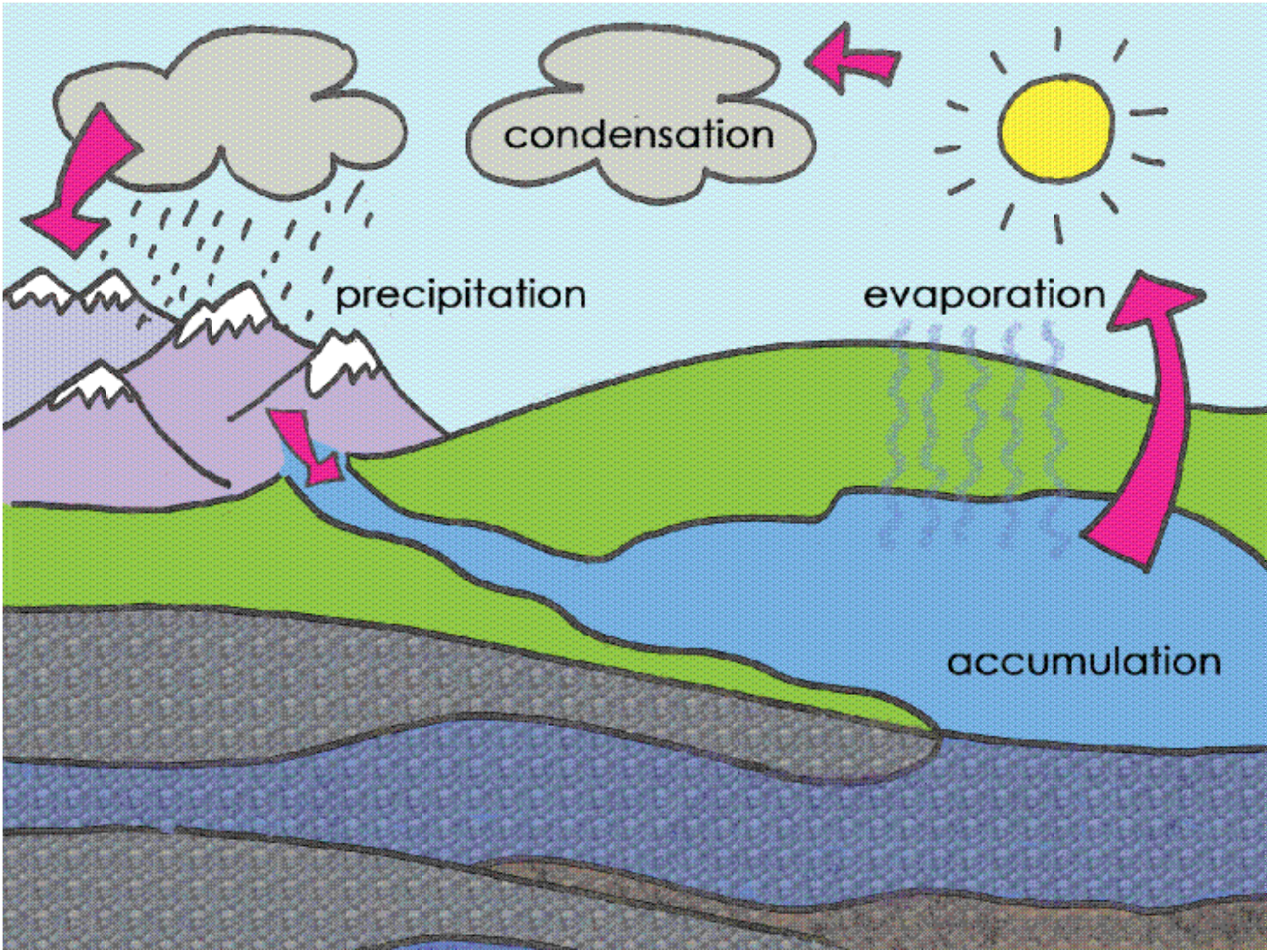
- Experiment distilling different kinds of solutions like juice, lemonade, water with dirt in it, etc.
- Experiment by using different bowls made from different materials like glass, metal, ceramic or plastic. Does transparency or opacity affect the rate of accumulation in the solar still?
- Observe when the water cycle happens through daily events such as when something is simmering with a lid on it, when condensation appears on the inside of a car windshield, or a bathroom mirror after a hot shower, etc.
- Write a creative story or cartoon strip about the journey a water molecule takes through the water cycle.

CA State Standards

Grade 4 Scientific Investigation and Experimentation 6c, 6d, 6f

Grade 5 Earth Sciences 3, 3a, 3b, 3c, 3d

Grade 6 Earth Sciences 4a


condensation
precipitation
evaporation
accumulation